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FORECASTING RISK OF DECISION – MAKING PROCESSES

Abstract: What is the risk of decision-making processes, what causes it? Most typically, definitions of risk are *ex post* – they are looking at risk as a difference between expectations of results of actions taken and the actual performance. This is a considerable inconvenience, especially in cases when processes are of a long-term nature. Thus, is it possible to measure risk in the course of the decision-making processes? How can this be done and in what conditions can risk measures be extrapolated? An analysis of the definitions of risk shows that the one which is the most useful for solving the problem undertaken in the present study, is given by K. and T. Jajuga, *"…the term of risk will refer to a decision, or, to be more precise, to an action taken as a result. One may therefore speak of taking risky decisions"*. The authors make it clear that a risky decision is uncertainty as to "*…the possibility for people to control the factors that determine the reality"*. This suggestion, if accepted, enables one to construct a risk model as a random vector whose components are control variables of the decision-making processes taking place. In consequence, this makes it possible to estimate statistic measures of risk. Risk measures indicating the level of risk at moment *t* of decision-making processes represent a foundation of the problem announced by the title of the present study. Although they are merely a set of risk estimations, i.e. an assessment of its state, they nevertheless provide an opportunity to forecast risk levels within the period in which the processes occur, thus providing valuable information for decisions-makers.

Keywords: risk, risk model, risk measures, risk states, forecasting risk states.

1. Introduction

Is risk something one should fear? Definitely yes, although not risk proper, but its consequences. Risk is a state inseparable from decision-making processes and has its source in a changing environment, with its various determinants differing from what has been accepted in plans. It is therefore a mistake to claim that risk can be managed, reduced, minimized or forecasted. If anything, we are able to monitor the consequences of risk. When measuring risk, we estimate the risk level at moment *t*, we manage under risk. If it is possible to extrapolate the state of risk onto the entire duration of decision-making processes, which is equivalent to the period of remaining under risk, then one may speak of forecasting risk states.

What is the risk of decision-making processes, what causes it? The scientific literature provides numerous definitions of the term, this fact being disturbing in itself, as when taking pains to present a conception of forecasting risk, one faces a task to choose a definition of risk, bearing in mind that the choice made has to allow for risk to be measured[1]. Most typically, definitions of risk are *ex post* – they are looking at risk as the difference between expectations of results of actions taken and the actual performance. This is a considerable inconvenience, especially in cases when the processes are of a long-term nature. Thus, is it possible to measure risk in the course of decision-making processes? How can this be done and in what conditions can risk measures be extrapolated?

2. Risk of decision-making processes

Decision-making processes related to the implementation of an organization's development plans are conditional in their nature – namely, they are determined by factors in the organization's environment that for obvious reasons cannot be ignored.

The business management theory distinguishes two separate spheres that affect decision-making processes: an organization's micro-environment, described by the literature of the subject as the industry-related environment, and a macro-environment – national and international factors. An organization is able to operate on condition of building its relations with the environment in a manner enabling activities that do not interfere with the essence of its strategic plans' status.

Regardless of whether this is about the organization's micro or macro-environment, these spheres do influence the organization through its stakeholders[2]. The stakeholders may or may not offer their resources and competence at the organization's disposal. The consequences of stakeholders' decisions are of major significance for the organization, as they affect its competitive position within the industry, its financial performance and, under extremely unfavourable market circumstances, they may even determine its survival on the market.

[1] F.H. Knight, *Risk Uncertainty and Profit*, University of Boston Press, Boston 1921; A.H. Willett, *The Economic Theory of Risk and Insurance*, University of Pennsylvania Press, Philadelphia 1951; K.J. Arrow, *Esej z teorii ryzyka*, PWN, Warszawa 1979, p. 56; R. Dobbins, W. Frąckowiak, S.F. Witt, *Praktyczne zarządzanie kapitałami firmy*, PAANPOL, Poznań 1992, p. 18; *Efektywność przedsięwzięć rozwojowych. Metody – analiza – przykłady*, R. Borowiecki (ed.), Akademia Ekonomiczna w Krakowie, Towarzystwo Naukowe Organizacji i Kierownictwa, Warszawa–Kraków 1996, p. 74; W. Grzybowski, *Ryzyko i sukcesy*, Uniwersytet Marii Curie-Skłodowskiej, Lublin 1996, p. 7; K. Jajuga, T. Jajuga, *Inwestycje. Instrumenty finansowe, ryzyko finansowe, inżynieria finansowa*, Wydawnictwo Naukowe PWN, Warszawa 1996, pp. 98–99; P. Jedynak, S. Szydło, *Zarządzanie ryzykiem*, Ossolineum, Wrocław–Warszawa–Kraków 1977, p. 19.

[2] The term applied to organization's strategic "supporters", see: K. Obłój, *Strategia organizacji*, PWE, Warszawa 1999. Definition of *stakeholders* is given by R.E. Freeman, *Strategic Management*, Pitman, Boston 1984, p. 53.

2.1. The organization's macro-environment

The macro-environment structure is a matter of convention, since even sets as disjointed as the organization's national (domestic) and international surroundings are intersecting, which means that the economic environment shows features of both the domestic surrounding and of the international one as well. These relations result from the tendency of national economies' growing interdependence, caused by strong integration trends or from the globalization of political and business relations. Global models of consumption, work, co-operation and leisure pastimes are increasingly determining not only the domestic environment. Although strongly associated with the local surroundings, legal and political factors are becoming international in their nature.

Internationally operating stakeholders have a special place in an organization's environment. Despite the blurring of borders between the domestic and foreign context, some groups of interests are clearly positioned in the international strategic environment: competitors, suppliers of materials, machine parts, components and technologies. With open economies, conducive to capital and know-how circulation, the activities of political and social groups of interests acting on behalf of and for the benefit of stakeholders are gaining importance.[3]

When analyzing how the environment influences an organization, one needs to bear in mind that it is impossible to develop a uniform, common macro-environment analysis for all organizations. Besides, the influence of administration and business authorities is non-existent or significantly limited by the situation in the national and foreign environment.[4]

2.2. The organization's micro-environment

It is sometimes difficult to identify stakeholders operating in the organization's surroundings. Some groups behave discretely and do not wish to be revealed, therefore their activities can only be evaluated through their effects. On the other hand, groups functioning in the organization's close market environment can be

[3] Business organizations' operations are influenced by subjects in their environment or groups inside it. These may offer their resources or competences to the organization or not, thereby determining its competitive position or financial performance significantly. G. Donaldson, J.W. Lorsch distinguish such internal stakeholders, as managers or influential employee groups and external stakeholders, such as financing groups (investors, owners, shareholders, stockholders, capital market institutions), groups of business, political and social interests /recipients, suppliers, competitors, central and local authorities, as well as their agencies, trade unions, local communities and community organizations, political and religious organizations, media. More about this important subject can be found in G. Donaldson, J.W. Lorsch, *Decision Making at the Top: The Shaping of Strategic Direction*, Basic Books, New York 1983, pp. 37–40.

[4] T. Gołębiewski, *Zarządzanie strategiczne. Planowanie i kontrola*, Difin, Warszawa 2001, p. 110 ff. Exceptions include some leading organizations or groups of organizations, capable of modifying the environment, e.g. through defining technology standards (Microsoft), trends in fashion (international fashion houses).

identified relatively easily. They are signalling their expectations and are visible enough for the strength of their influence to be rated[5]. An organization's stakeholder relations can be cooperative or competitive[6].

Local political preferences diversify the rate of business sectors' growth. Environmental regulations focusing on the achievement of regional benefits, the development of local banks familiar with the needs of their customers, local communities' changing awareness and lifestyle – all these factors are sending clear messages to the organization, thereby supporting the production of organic food, sports and leisure equipment or stimulating the development of leisure pastime related services.

3. Risk model. Risk measures

Business management under risk involved in decision-making processes can be controlled effectively, providing that the value of risk is measurable. This problem requires adopting a definition of risk, which allows for risk to be measured.

Both the theory and the practice of management assume control of the decision-making processes' quality to be based on the monitoring of changes within the processes control variables that have been identified. The cause and effect relations between control variables and the level of threats to the achievement of goals are characteristic to these control processes. These relations constitute the foundations of the risk model construction. With some specific assumptions, this model is a random vector, with the decision-making process control variables as components[7].

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[5] I.C. McMillan, P.E. Jones, *Strategy Formulation: Power and Politics*, West Publishing, St. Paul 1986, p. 46. K. Obłój, *Strategia organizacji*, PWE, Warszawa 1999, p. 118, offers a simple, while effective solution for identifying and measuring the power of stakeholders' influence on the organization, and the strength of relations between various stakeholders. The author defines a matrix, with values indicating the strength of stakeholders influence as elements. Solving the problem of measuring the strength of such relations is another issue, and an especially complicated one in the case of groups that are not revealing their interests.

[6] The organization's relations with its competition are a classic example of competitive relations. Cooperative relations are not encountered in such a pure form – they are a result of a compromise that restricts one of the parties to the cooperation agreement in their striving for domination.

[7] Let us assume that $\{X_1, X_2, ..., X_n\}$ is a set of the decision-making process control variables and that $f(x_1, x_2, ..., x_n)$ is a function of probability distribution density of random vector $X = \{X_1, X_2, ..., X_n\}$ with distribution parameters $\Lambda\ (\mu, \sigma) / \mu = (\mu_1, \mu_2, ..., \mu_n),\ \sigma = (\sigma_1, \sigma_2, ..., \sigma_n)$. Assuming that the distribution of function *f* follows a normal distribution, the function's analytical form can be expressed as:

$$f(X) = \frac{1}{(2\pi)^{n/2}\sqrt{M}} \exp\left(-\frac{1}{2}(X-\mu\right) M^{-1}(X-\mu)^T,$$

where $M = \begin{pmatrix} \sigma_1^2 & \eta_{12} & \dots & \eta_{1n} \\ \eta_{21} & \sigma_2^2 & \dots & \eta_{2n} \\ \dots & \dots & \dots & \dots \\ \eta_{n1} & \eta_{n2} & \dots & \sigma_n^2 \end{pmatrix}$,

σ_j^2 – variances of variables X_j, η_{ij} – covariances of variables X_i, X_j, $i, j = 1, 2, \dots, n$.

It is possible to measure risk with a risk model based on two results of monitoring relevant to the decision-making in compliance with the guidelines accepted for the business organization's development plans. Assuming that risk model components *X* are continuous functions, and *f*(*X*) is a function of *X* probability distribution density, statistical measures of risk can be defined[8]:

1. The probability that components of risk model $\{X_1, X_2, ..., X_n\}$ take values from the set $[a_1, b_1] \times [a_2, b_2] \times, ..., \times [a_n, b_n]$:

$$P\left(a_1 \le x_1 \le b_1, a_2 \le x_2 \le b_2, ..., a_n \le x_n \le b_n\right) = \int_{a_1}^{b_1}\int_{a_2}^{b_2}...\int_{a_n}^{b_n} f(x_1, x_2, ..., x_n)\, dx_1 dx_2, ..., dx_n.$$

2. The vector of risk model components expected values:
$E(X) = \left(E(X_1), (E(X_2), ..., E(X_n)\right),$

$$\forall_{i=1,2,...,n}\; E(X_i) = \int_{a_i}^{b_i} x_i \left[\int_{a_1}^{b_1}...\int_{a_{i-1}}^{b_{i-1}}\int_{a_{i+1}}^{b_{i+1}}...\int_{a_n}^{b_n} f(x_1, x_2, ..., x_n) dx_1 ... dx_{i-1} dx_{i+1} ... dx_n\right] dx_i.$$

3. The vector of risk model components variance:
$Var(X) = \left(Var(X_1), (Var(X_2), ..., Var(X_n)\right),$

$$\forall_{i=1,2,...,n}\; Var(X_i) =$$

$$= \int_{a_i}^{b_i} [x_i - E(X_i)] \left[\int_{a_1}^{b_1}...\int_{a_{i-1}}^{b_{i-1}}\int_{a_{i+1}}^{b_{i+1}}...\int_{a_n}^{b_n} f(x_1, x_2, ..., x_n) dx_1 ... dx_{i-1} dx_{i+1} ... dx_n\right] dx_i.$$

4. Covariances of risk vector components:

$$\text{cov}\left(X_i, X_j\right) = \int_{a_i}\int_{a_j} [x_i - E(X_i)][x_j - E(X_j)]\, g(x_i, x_j) dx_i dx_j,$$

where:

$$\forall_{i\, j=1,2,...,n} \wedge i \ne j\;\; g\left(x_i, x_j\right) =$$

$$= \int_{a_1}^{b_1}...\int_{a_{i-1}}^{b_{i-1}}\int_{a_{i+1}}^{b_{i+1}}...\int_{a_{j-1}}^{b_{j-1}}\int_{a_{j+1}}^{b_{j+1}}...\int_{a_n}^{b_n} f(x_1, x_2, ..., x_n)\, dx_1 ... dx_{i-1}, dx_{i+1} ... dx_{j-1} dx_{j+1} ... dx_n.$$

4. The state of risk. Forecasting risk

The state of the decision-making process risk is defined by its measures at a certain moment of the business organization's operations aimed at the achievement of its planned goals.

[8] See also: J. Zemke, *Ryzyka zarządzania organizacją gospodarczą*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2009, pp. 102–107.

Definition. The state of risk at moment *t* is a set of four statistical measures of the risk vector:

$$SR^{(t)}(P^{(t)}(X), E^{(t)}(X), Var^{(t)}(X), Cov^{(t)}(X)) \quad (1)$$

Risk state measures are not typologically homogeneous – the probability that risk vector components take values from certain intervals of variability – $P(X)$ is a scalar, the risk vector expected value and variance – $E(X)$, Var(X) are vectors, whereas variances and covariances of the risk vector components – cov(X) = cov(X_i, X_j), where $i, j = 1, 2, ..., k$ and $i \neq j$ are defining a k-dimensional square matrix.

Let us assume that the state of risk was estimated in time interval $[t, t + 1]$ – this gives us information that ($P^{(t)}(X)$, $E^{(t)}(X)$, Var$^{(t)}(X)$, Cov$^{(t)}(X)$) and ($P^{(t+1)}(X)$, $E^{(t+1)}(X)$, Var$^{(t+1)}(X)$, Cov$^{(t+1)}(X)$) The relation between $SR^{(t)}$ and $SR^{(t+1)}$ provides essential information for the evaluation of the direction and the dynamics of the decision-making processes risk.

Does the monitoring of changes in risk measures at subsequent moments $[t, t + 1]$ provide a complete picture of changes in risk of the decision-making process? One should believe that this is a picture partly reflecting risk fluctuation in a time interval, where $\Delta t = (t + 1) - t$. According to the definition, risk is a difference between the expectations specified in the organization's development plans and the actual performance, therefore statistical measures of risk should be estimated based on the values from the set $[a_{01}, b_1^t] \times [a_{02}, b_2^t] \times, ..., \times [a_{0n}, b_n^t]$ [9].

1. The probability that at moment *t* risk model components $\{X_1, X_2, ..., X_n\}$ will take values from the set $[a_{01}, b_1^t] \times [a_{02}, b_2^t] \times, ..., \times [a_{0n}, b_n^t]$:

$$P^t\left(a_{01} \le x_1 \le b_1^t, a_{02} \le x_2 \le b_2^t, ..., a_{0n} \le x_n \le b_n^t\right) =$$
$$= \int_{a_{01}}^{b_1^t} \int_{a_{02}}^{b_2^t} \dots \int_{a_{0n}}^{b_n^t} f(x_1, x_2, ..., x_n)\, dx_1 dx_2, ..., dx_n.$$

2. The vector of risk model components values expected at moment *t* $E^t(X) = \left(E^t(X_1), (E^t(X_2), ..., E^t(X_n)\right)$:

$$\forall_{i=1,2,...,n} \; E^t(X_i) = \int_{a_{0i}}^{b_i^t} x_i \left[\int_{a_{01}}^{b_1^t} \dots \int_{a_{0i-1}}^{b_{i-1}^t} \int_{a_{0i+1}}^{b_{i+1}^t} \dots \int_{a_{0n}}^{b_n^t} f(x_1, x_2, ..., x_n) dx_1 ... dx_{i-1} dx_{i+1} ... dx_n \right] dx_i.$$

[9] Risk model components { } are random variables and at any moment *t* they are taking values $x_i \in [a_{0i}, b_i^t]$, $i = 1, 2, ..., n$, $\{a_{0i}\}$ and $\{b_i^t\}$ are respectively the values taken by control variable X_i in time interval [0, *t*], moment 0 corresponds with value $X_i = x_{0i}$ accepted in plans, whereas $X_i = x_i^t$, is the value of variable X_i at moment *t*. This significant modification of the reference base for risk at moment *t* in relation to risk estimated based on statistical measures of risk, computed with the decision-making processes control variables assumed in the business organization's plans, takes into account the definition of risk accepted for this study.

3. The vector of risk model components variance at moment t $\mathrm{Var}^t(X)=\left(\mathrm{Var}^t(X_1),(\mathrm{Var}^t(X_2),...,\mathrm{Var}^t(X_n)\right)$:

$$\forall_{i=1,2,...,n}\ Var^t(X_i)=$$

$$=\int_{a_{0i}}^{b_i^t}[x_i-E^t(X_i)]\left[\int_{a_{01}}^{b_1^t}...\int_{a_{0i-1}}^{b_{i-1}^t}\int_{a_{0i+1}}^{b_{i+1}^t}...\int_{a_{0n}}^{b_n^t}f(x_1,x_2,...,x_n)dx_1...dx_{i-1}dx_{i+1}...dx_n\right]dx_i.$$

4. Covariances of the risk vector components at moment t:

$$\mathrm{cov}^t\left(X_i,X_j\right)=\int_{a_{0i}}^{b_i^t}\int_{a_{0j}}^{b_j^t}[x_i-E^t(X_i)][x_j-E^t(X_j)]g^t(x_i,x_j)dx_idx_j,$$

where:

$$\forall_{i\,j=1,2,...,n}\wedge i\neq j\ \ g^t\left(x_i,x_j\right)=$$

$$=\int_{a_{01}}^{b_1^t}...\int_{a_{0i-1}}^{b_{i-1}^t}\int_{a_{0i+1}}^{b_{i+1}^t}...\int_{a_{0j-1}}^{b_{j-1}^t}\int_{a_{0j+1}}^{b_{j+1}^t}...\int_{a_{0n}}^{b_n^t}f(x_1,x_2,...,x_n)dx_1...dx_{i-1},dx_{i+1}...dx_{j-1}dx_{j+1}...dx_n.$$

Let $SR^{(b)}$ i.e. $(P^b(X),E^b(X),Var^b(X),Cov^b(X))$ is the "basic state of risk"[10]. The risk state components are estimated based on decision-making processes control variables values assumed in the organization's development plans.

Definition. Changes in risk at moment t are defined by relations between risk components within the interval $[0, t]$, $t=1,2,...,\tau$, i.e.

$$\Delta SR^t=(r_1[P^b(X),P^t(X)],r_2[E^b(X),E^t(X)],\ r_3[Var^b(X),Var^t(X)],r_4[Cov^b(X),Cov^t(X)])^{11}. \qquad (2)$$

[10] Components $\{X_1,X_2,...,X_n\}$ will take values from the set $[a_{01},b_{01}]\times[a_{02},b_{02}]\times,...,\times[a_{0n},b_{0n}]$. The term "basic state" has been defined for the purpose of the present study and means an assumption made in the plans as regards variability intervals of the planned decision-making processes control variables.

[11] Definitions of relations between risk variability components: $r_1=(P^t(X)-P^b(X))$,, $r_2=d\left(E^t(X),E^b(X)\right),r_3=d\left(\mathrm{Var}^t,\mathrm{Var}^b\right),r_4=r\left(\mathrm{Cov}^t,\mathrm{Cov}^b\right)$. Two vectors are given: $X=(x_1,x_2,...,x_n)$, $Y=(y_1,y_2,...,y_n)$, where $X,Y\in R^n$ and a certain symmetrical, positive-definite matrix C. Measure $d(X,Y)=\sqrt{(X-Y)\,C^{-1}\,(X-Y)^T}$ represents the distance between vectors $X,Y\in R^n$ as defined by Mahalanobis in the paper "On the generalised distance in statistics" published in *Proceedings of National Institute of Science of India* 2, 1936, pp.49–55]. Relations (r_2,r_3) are defining the distance between vectors $\left(E^t(X), E^b(X)\right)$ and $\left(\mathrm{Var}^t(X),\mathrm{Var}^b(X)\right)$. When interpreting relation (r_4) I am using the geometric interpretation of formula $\sqrt{(X-Y)\,C^{-1}\,(X-Y)^T}$. In space R^n this is a set of points equally distant from the central point determined by the basic risk state, this set forming a hyperspherical ellipsoid. At moment t in relation to the basic state, information about changes in this component of the risk state is represented by a rotation at a certain angle towards the coordinate system,

Relations $\{r_i\}$, $i = 1,2,3,4$ show changes between risk state $SR^{(t)}$ in relation to components of risk state $SR^{(b)}$ at any moment *t*, estimated based on the assumptions accepted in the organization's development plan, i.e. set $[a_{01}, b_{01}] \times [a_{02}, b_{02}] \times, ..., \times [a_{0n}, b_{0n}]$.

In practice, the issue of forecasting risk is associated with estimating forecasts of changes in the organization's environment – control variables $\{X_i\}$ – where the decision-making processes are carried out. Through approximating a sequence of elementary events $\{x_i^t\}$ $/ x_i^t \to f^{(i)}(x_i^t)$, $t \in [1, \ \tau] /$ by continuous function *f*, one is able to extrapolate the function within interval $[\tau + 1, \ \tilde{A}]$[12].

To estimate risk forecasts at moment $T \in [\tau + 1, \Gamma]$ one needs to estimate the value of its components on the set $[a_{01}, b_1^T] \times [a_{02}, b_2^T] \times, ..., \times [a_{0n}, b_n^T]$, $X_i^T = x_i^T$, $b_i^T = x_i^T$, $i = 1, 2, ..., n$, and as a result:

$$\Delta SR^T = (r_1[P^b(X), P^T(X)], r_2[E^b(X), E^T(X)],$$
$$r_3[Var^b(X), Var^T(X)], r_4[Cov^b(X), Cov^T(X)]).$$

The concept of forecasting risk presented in this study is based on forecasts of the upper limits of integrals representing statistical measures of risk involved in the decision-making processes. The fact of choosing $/ x_i^t \to f^{(i)}(x_i^t)$, $t \in [1, \ \tau] /$ mapping determines the set of information about decision-making processes control variables. Depending on the stock of information possessed, one may assume that approximants of variables $f^{(i)}$ are functions of a growing tendency, and this does not preclude risk components to represent a picture of compound phenomena. In a case like this, changes can be described using information on the decision-making processes control variables associated directly with the risk consequences observed[13].

5. Conclusions

Forecasting risk states is crucial to the quality of a business organization management under risk, as it provides a basis for defining selection criteria as regards effective measures of protection against the effects of risk that has been taken.

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the length of ellipsoid axes may also change. The angle of the rotation is determined by the matrix of the own vectors of matrix ***C***, while the lengths of the hyperspherical ellipsoid axes are determined by square roots of matrix **C** own roots.

[12] An overview of methods of smoothing time series is presented in Chapter 3 by P. Dittmann, published in a collective work *Prognozowanie gospodarcze. Metody i zastosowania*, M. Cieślak (ed.), Wydawnictwo Naukowe PWN, Warszawa 1997.

[13] Control variables of the decision-making processes may represent a picture of simple or compound events, depending on the completeness of the description. A precise description can be obtained by means of one factor only – a simple phenomenon, but in some cases this quality of description can be obtained no sooner than when it comprises more than one change – a compound phenomenon, see: *Prognozowanie gospodarcze*..., p. 17. Whether such a set of factors can be identified, is another question.

Risk has its source in the environment where the decision-making processes are implemented. This thesis is supplemented by another one, where a risk model constructed based on control variables of the decision-making processes enables one to measure risk, and thereafter, its level and status at a certain time point of the process.

The introduction to the present study emphasizes the necessity of developing a concept of forecasting risk of the decision-making processes carried out by those managing business organizations.

The first and the second section of the paper contain a multi-strand, but consistent description, which begins with a definition of risk involved in a decision-making process. This resolution opens the next stage of analysis, leading to the construction of a risk model. The model of risk using control variables of the decision-making processes is consistent with the management theory referred to in the initial part of the study, recommending the decision-making processes to be controlled through monitoring control variables of the actions being taken. A model built in this way is a random vector, its components being random variables identical with the decision-making process control variables. The following statistical measures are natural measures of the risk model: the probability that the risk vector components will take values from certain variability intervals, the vector of components expected values, the vector of components variances, the matrix of the risk vector components variances and covariances.

In the third part of the study, a risk state definition and a definition of changes occurring at a definite time point of the decision-making process has been developed. A concept of forecasting risk status is presented here. The estimated risk state measures are used as a basis for the presentation of modelling changes in risk states over time. The extrapolation of functions that have been constructed here is equivalent to risk state forecasts.

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PROGNOZOWANIE STANÓW RYZYKA PROCESÓW DECYZYJNYCH

Streszczenie: Czym jest ryzyko procesów decyzyjnych, czym jest powodowane? Literatura naukowa podaje wiele definicji pojęcia, co już jest niepokojące, ponieważ podejmując trud przedstawienia koncepcji prognozowania stanów ryzyka, stajemy przed wyborem definicji ryzyka, pamiętając o tym, by dokonany wybór umożliwiał jego pomiar. Definicje ryzyka mają najczęściej charakter *ex post*, postrzegają ryzyko jako różnicę pomiędzy oczekiwaniami dotyczącymi rezultatów podejmowanych działań a rezultatem zrealizowanym. Stanowi to istotną niedogodność, szczególnie w przypadkach gdy procesy decyzyjne są realizowane w długim okresie. Czy zatem możliwy jest pomiar ryzyka w trakcie realizacji procesów decyzyjnych, jak tego dokonać i w jakich uwarunkowaniach można ekstrapolować miary ryzyka? Analizując definicje ryzyka, tę, która jest najbardziej przydatna w rozwiązaniu podjętego w tym opracowaniu zagadnienia, podają K. i T. Jajuga, „…termin ryzyko odnosić będziemy do decyzji, a właściwie do działania podjętego w jego wyniku. Można mówić przeto o podejmowaniu ryzykownych decyzji". Autorzy jednoznacznie postrzegają decyzję ryzykowną jako niepewność co do „…możliwości kontrolowania przez ludzi czynników kształtujących rzeczywistość". Przyjęcie tej sugestii pozwala zbudować model ryzyka tożsamy z wektorem losowym o składowych będących zmiennymi kontrolnymi realizowanych procesów decyzyjnych. Umożliwia to w konsekwencji oszacowanie statystycznych miary ryzyka. Miary ryzyka określające stan ryzyka w momencie *t* realizowanych procesów decyzyjnych stanowią fundament zagadnienia, które zapowiada temat pracy. Chociaż są jedynie zbiorem oszacowań ryzyka, a więc oceną jego stanu, to otwierają możliwość prognozy stanów ryzyka w okresie realizacji procesów, co jest cenną informacją dla realizujących procesy decyzyjne.

Słowa kluczowe: ryzyko, model ryzyka, pomiar ryzyka, stan ryzyka, prognozowanie stanu ryzyka.